BMAA TECHNICAL INFORMATION LEAFLET (TIL)
STANDARD MINOR MODIFICATION
SMM 117 – LiFePO4 BATTERY DIRECT REPLACEMENT
(INCL. REMOVABLE TYPES)
ISSUE – 3
APRIL 2021

Introduction

This leaflet contains the required information to permit the straightforward fitment of a Lithium Iron Phosphate (LifePO4) battery in place of a standard lead-acid battery in a BMAA aeroplane.

It permits only specific ways of doing this, which are known to be straightforward and minimise risk. It does not mean that there are not other ways of replacing your battery, such as repositioning the battery. If you wish to do it another way, this must be done through a more conventional mod application (at potential greater cost). The BMAA Technical Office will request more information than is required here.

Notwithstanding the simple approach taken by this TIL, it is the aircraft owner's responsibility to ensure that all materials used in a modification are of adequate quality. Proper aircraft engineering standards are applied, and that this modification does not create any safety problem when combined with any other modification to the aircraft. No relevant information must be withheld from the BMAA or Inspector.

Modern LiFePO4 battery chemistry is more stable than other forms of Lithium cell, but it is still much more reactive than lead-acid cells. For this reason, BMAA Technical Office (and CAA) must employ additional safety measures. Another important reason for continued oversight of lithium battery fitment is to ensure LiFePO4 batteries and not other lithium-ion batteries are being fitted.

Notes:

- The LiFePO4 chemistry is understood to be fundamentally reasonably safe, particularly concerning thermal runaway, which can be a significant problem with other lithium-ion chemistries. The LiFePO4 chemistry does not readily give up its oxygen, even at high temperature, which is the cause of fire and explosion with other lithium-ion chemistries.

- LiFePO4 batteries have a significantly higher energy density than lead-acid batteries, which permits significant weight saving.

- LiFePO4 batteries have a very high-power density, even compared to other lithium-ion chemistries, which makes them eminently suitable as starting batteries. Although the energy density of LiFePO4 batteries is not as high as some other lithium-ion batteries, this is not critical for a starting battery.

- Confusingly, the LiFePO4 chemistry – sometimes just called lithium iron, or LiFe – is one of several lithium-ion battery chemistries.

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Battery Approval List

Batteries currently cleared for use on BMAA aircraft (note that others not listed may also be cleared by the BMAA)

Manufacturer	Model
Aliant	X Series & XP-Series
EarthX	ETX18B
Exide	ELTX20
JMT	YTX14H-FP
Powerlite	PS Series
RAM Batteries	Performance Series (5Ah & 7.5Ah)
Shorai	LFX 14 Series
Skyrich	HJTX14H-FP-SWI
Super B	SB12V5200, SB12V7800P
Varley	Li-16, Li-5, Li-3

Approval basis for LiFePO4 batteries

The standard requirement for batteries in BMAA aircraft is BCAR Section S requirement S1353.

S1353 Storage battery design and installation

a) Each storage battery must be designed and installed as prescribed in this paragraph.
b) No explosive or toxic gases emitted by any battery in normal operation, or as the result of any probable malfunction in the charging system or battery installation, may accumulate in hazardous quantities within the aeroplane.
c) No corrosive fluids or gases that may escape from the battery may damage surrounding structures or adjacent essential equipment.

Following discussions with the CAA, CS-23.1353 and a draft EASA Special Condition for lithium batteries have been used for guidance. For a starting battery, whose failure (to continue to provide electricity) or manual disconnection (from the aircraft's electrical system) does not unduly hazard the aircraft, the conclusion drawn from this guidance material was that, in addition to the existing requirements of S1353, a LiFePO4 battery should not be unduly hazardous to aircraft or occupants if accidentally short-circuited for a prolonged period (e.g. starter motor solenoid malfunction), over-charged (e.g. rectifier malfunction), or damaged in an accident.

LiFePO4 BMAA approval history

Previous BMAA approvals of LiFePO4 batteries were on the following basis:

- The battery was a LiFePO4 battery, not another type of lithium-ion battery.
- The manufacturer markets the battery as a replacement for a lead-acid vehicle starting battery and suitable for charging with a standard vehicle charging system.

- The battery was not unduly hazardous if accidentally short-circuited for a prolonged period (e.g. starter motor solenoid malfunction).
- The battery was not unduly hazardous if over-charged (e.g. rectifier malfunction).
- The battery was not unduly hazardous if damaged in an accident.

For the first two BMAA approvals, short-circuit, over-charge and accident damage tests were performed by the applicants.
The applicants made up their own test specifications. The batteries behaved very benignly, with no fire or explosion and limited leaking or venting.

Subsequent BMAA approvals have been based on UN DOT 38.3 certification, which requires the manufacturer to have demonstrated that the battery passes several tests, including short-circuit, over-charge and accident damage tests.

UN DOT 38.3 Certification

This certification is based on the United Nations' requirements for lithium battery testing prior to transportation:

Tests are specified for:

1. Altitude simulation
2. Thermal test
3. Vibration
4. Shock
5. External short circuit
6. Impact / crush
7. Overcharge
8. Forced discharge

A rechargeable battery is subjected to tests 1 to 5 and 7. Its constituent cells are tested to at least tests 6 and 8.

The only real concern that has been identified over the applicability of the UN DOT 38.3 tests to BMAA aircraft is that the pass criteria for the overcharge test are only no disassembly (explosion) and no fire; rupture and venting are permissible. This video shows that extreme overcharging can cause smoke to be expelled, which could be hazardous in an enclosed cockpit: tinyurl.com/kqrxkef. For this reason, it is required that a voltmeter be fitted if a LiFePO4 battery is fitted inside an enclosed cockpit, and a means of isolating the charging circuit should over-voltage occur.

The pass criteria for the short-circuit test are no disassembly (explosion), no rupture and no fire, although venting is permissible (if the battery is designed to vent). The only likely 'short circuit' condition is a starter motor solenoid malfunction which will tend to occur on the ground. The voltmeter will indicate any 'short circuit' condition.

Standard Minor Modification Approval

Requirements on an aircraft for it to be suitable to be modified (using the SMM):

- The aircraft is currently fitted with a lead-acid starting battery, which is to be replaced with a LiFePO4 starting battery. The lead-acid starting battery fitment is approved.
- The aircraft's engine continues to run if the master switch is turned off.

- If the battery is in an enclosed cockpit, a voltmeter is fitted to monitor charging.
- If the battery is in an enclosed cockpit there must be a means to isolate the battery from the charging system and the rest of the aircraft's DC system. A circuit breaker is an acceptable means of compliance.

Requirements on a lithium battery for it to be suitable as a direct replacement for a lead-acid starting battery:

- The battery is a LiFePO4 battery, not another type of lithium-ion battery, and marketed by the manufacturer as a replacement for a lead-acid vehicle starting battery and suitable for charging with a standard vehicle charging system.
- UN DOT 38.3 Certification has been confirmed for the LiFePO4 battery by the manufacturer to the BMAA Technical Office's satisfaction.

Requirements on the installation (using the SMM):

- The aircraft's charging voltage meets the criteria provided by the battery manufacturer. Note that the two-stroke Rotax engine regulator rectifier may not provide a sufficiently smooth voltage that is suitable for a LiFePO4 battery. A check with an oscilloscope will show if voltage spikes are present.
- The battery manufacturer's installation instructions are followed.
- The LiFePO4 battery is a suitable replacement for the existing lead–acid battery in terms of voltage, starting current, and capacity.
- The LiFePO4 battery is not larger than the existing lead-acid battery.
- The LiFePO4 battery fits in the same location as the existing lead-acid battery. Most batteries come with additional packing material to allow for the smaller size of the LiFePO4 battery.
- A new or amended weight and balance report has been generated and is satisfactory.
- If a voltmeter is required, it is marked to show an overcharge condition.
- If a charge isolation switch/circuit breaker is required, it is marked for operation.

Standard Minor Modification compliance with approval basis

S23 Load Distribution Limits
Amended weight and balance report required.

S25 Weight Limits
Replacement battery not more massive than approved original.

S597 Loads from Single Masses
Replacement battery not more massive than approved original.
Replacement battery in same location as approved original.
Changes to approved installation not significant from structural perspective.

S1165 Engine Ignition Systems
Engine continues to run when isolated from battery.

S1301 Equipment – Function and Installation
If there is a battery problem and the pilot decides to isolate the battery using the master switch, power to any EFIS will be lost. This is no different to any other electrical problem requiring the master switch to be turned off.

S1307 Miscellaneous Equipment
Voltmeter required if battery in enclosed cockpit.

S1353 Storage Battery Design and Installation
Battery has UN DOT 38.3 certification.
Voltmeter required if battery in enclosed cockpit.
Charging circuit required to be isolated if battery in enclosed cockpit.
Installation essentially unchanged from approved original.

S1365 Electric Cables and Equipment
Unchanged from approved original.

Important Charging Note

Follow the battery manufacturers guidelines for charging each LiFePO4 battery. Do not use a standard lead-acid charger unless the manufacturer specifically says this is okay. Lead-acid chargers are optimized for different battery technology and use charging and safeguarding methods, which are not always suitable for LiFePO4 batteries.

A placard should be applied next to the battery terminals saying:

LiFePO4 Battery Fitted
Use LiFePO4 Battery Charger Only

Returning the Form

After fitting the battery, and having the modification inspected by a BMAA Inspector, the form must be sent to the BMAA Technical Office for approval. It is acceptable to send in the form with your Permit revalidation form, noting in the modifications box 'TIL 117 submitted'.

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BMAA – STANDARD MINOR MODIFICATION CHECKLIST: TIL 117

Reg: G-_ _ _ _	Aircraft type:	Serial No:
Owners name[1]:		Owners BMAA No:
[1] BMAA Aircraft Ownership Trustee Grid required for syndicate/group/company owned aircraft		

Battery Details

No.	ACTION	COMMENTS	INSPECTOR INITIALS
1 Old Battery			
1.1	Make and Model		
1.2	Weight and Dimensions	Wt: Dims:	
	New Battery		
1.3	Make and Model		
1.4	Weight and Dimensions	Wt: Dims:	
1.5	Battery On BMAA Approval List *(If Battery Not Listed Check With BMAA Technical Office For Approval)*		

Safety Checks

2 New Battery Installation Checks			
2.1	Battery Capabilities Suitable		
2.2	Manufactures Instructions Available and Followed		
2.3	Battery Fits Existing Box		
2.4	Battery Box Location		
2.5	Any Packing Require – If yes state what used		
2.6	Battery Not In Close Proximity (100mm or less) to any powerful heat source/s (i.e. manifold, exhaust system)		
2.7	Battery Fitted Securely In Mount: Forward 9g, Upward 4.5g, Downward 4.5g & Sideward 3g.		
2.8	Battery Cables Terminals Fit New Battery		
2.9	Terminals adequately insulated and connected		
2.10	Aircraft charging Voltage within battery voltage limits		
2.11	**Battery Charging Warning Placard** visible next to battery terminals		
2.12	Weight Change		

2.13	Estimated CG Change (3 axis) Forwards/Aft Still within limits. **For batteries mounted some distance from the CG i.e. towards the tail, aircraft should either be re-weighed and report submitted with application or the new cg calculated accurately.**		
3 For Battery Located In Enclosed Cockpit			
3.1	Voltmeter Fitted and Marked for Overcharge Condition		
3.2	Charging Circuit able to be isolated. (Either switch or circuit breaker which can be pulled for off)		
3.3	Switch/Circuit Breaker Placarded for operation		
4 Operation			
4.1	Conduct Test of Aircraft Starting System, satisfactory?		
4.2	Master Switch Isolates Battery from DC Circuits.		
5 Documentation			
5.1	Following documents to be kept with aircraft records: ○ Manufacturer's fitting instructions; ○ Invoices for all parts; ○ Correspondence with BMAA Technical Office.		
5.2	Modification recorded in airframe logbook.		
5.3	Weight and balance report amended; modified aircraft continues to comply with the weight and balance requirements of the TADS / HADS. See 2.13 above.		

OWNER'S DECLARATION		
I declare that the foregoing information is correct to the best of my knowledge and I will not change the installation design once approved.		
Signed:	Name.	Date:

INSPECTOR'S DECLARATION		
I declare that the foregoing information is correct and the installation is fit to be flown.		
Signed:	BMAA Inspector Name: BMAA Inspector #: BMAA Member #:	Date:

This form must be sent with payment as per current fees in MF or www.bmaa.org, and BMAA Aircraft Ownership Trustee Grid (if applicable) to*:- technical.office@bmaa.org

BMAA Office Approval:	**(signed)**	**(Name)**
Mod No.: G-_ _ _ _ / TIL117 / 20 _ _ /_ _ _ _ _		**(Date)**

**Whilst waiting for this form to be returned by the BMAA the aircraft may be flown for up to one calendar month from the Inspection date above. Once this form is returned to you signed please enter the full modification approval number above in your aircraft logbook and retain this sheet with your aircraft records.*